Energy-Water Nexus
Western Region Workshop

Problems and Needs Summary

Priority Problem: Electricity Transmission and Distribution/Technology Integration

The Western region faces significant electricity transmission and distribution challenges—

- The region is characterized both by large, growing load centers (urban areas) that are widely dispersed geographically and by small, widely dispersed small load centers (rural areas). These are served by large, centralized electricity generating facilities, a paradigm that participants feel is outdated and unsustainable over the long-term.
- The region's transmission infrastructure is generally aligned north-south, making it difficult to move electricity from states in the eastern part of the region to consumers in the western parts of the region.
- The aging and outdated transmission infrastructure is running at close to capacity, and few new lines are being planned. This results in transmission congestion and bottlenecks, cutting off suppliers from consumers; it can also force suboptimal use of water and fossil fuel resources by forcing generation into inappropriate (resource scarce) areas.
- The Western region's transmission and distribution system differs from other regions' in that the states of California, Oregon, Arizona, and Nevada are among the nation's leaders in developing and integrating renewable and other intermittent electricity generating technologies. These technologies present problems of grid integration and management and power dispatch (the conventional grid likes predictable production of energy, not generation that comes on unexpectedly and can drop off suddenly).
- New renewable energy technologies and applications present regulatory challenges—often, the regulatory and legal framework surrounding water and energy is not sufficiently flexible to allow promising applications of new technologies.
- The grid in the western region—like other regions—lacks the ability to optimize the integration of various generation technologies (hydropower, renewables, fossil, etc.), and in particular lacks the tools to manage short term storage, dispatch, and management of intermittent sources. This is a grid and technology issue; participants also note that the problem is an infrastructure design issue (i.e., Problem is an infrastructure design issue—how to design renewable systems to mesh with the conventional grid).

To address these challenges, participants identified the following research needs:

- **An integration study of the impacts, benefits, and costs of large-scale/high-penetration of wind and other intermittent sources on grid operations.** Such an integration study will need to identify and quantify the issues related to intermittent supply of electricity to the grid. Participants call for the Department of Energy to **undertake collaborative research with European Union organizations/companies** that are much more advanced in the area of renewable energy technologies and their incorporation into the power grid.
- **Expanded basic and applied R&D on power storage technologies** (batteries, superconductors, pumped storage) and control technologies to facilitate the integration of intermittent technologies into the grid and enable the grid to more quickly respond to sources coming on and off-line. Participants note that much work has been done in the past (by EPRI in particular), and that this work can be used as a platform for enhanced

work. In parallel with R&D work, studies should be conducted to evaluate the environmental and economic impacts of large-scale storage technology introduction.

- **Development of new materials and technologies for transmission lines** in an effort to increase the carrying capacity of existing infrastructure. Participants in particular cite the need for research to enable a shift from copper to carbon transmission lines. In parallel with this, participants also note a need for research to examine and understand line losses and develop means to reduce those losses.
- **Examine the value of electrical power from residential feeds** into the grid at peak demand intervals. Develop off peak incentives to optimize use of off-peak energy (e.g., electric vehicle recharge).
- **Develop peak shifting technologies.** Participants note that air quality standards are reducing the ability to use some peaking plants, thus the need for technologies and methodologies that can shift or reduce peak electricity demand.

In addition to these research and development activities, participants also mentioned a host of complementary policy-related activities that deserve consideration:

- **Develop streamlined permitting process for transmission and distribution projects**. Participants note that competing missions and goals between federal agencies, when overlain on state and local bureaucracies, creates a permitting process that is extraordinarily unwieldy and expensive to navigate.
- **Participants question if DOE should re-examine and revamp the role of FERC** and streamline its re-licensing processes, and if a legal analysis is required to assess where gaps exist.
- **Create a mechanism to encourage construction of transmission and distribution infrastructure.** Participants note that deregulation has resulted in underinvestment in the grid and fragmentation of its management, and that some external incentives are necessary to spur necessary construction.
- **Improve cooperation between DOE and utilities.** Participants note a disconnect between DOE and utilities, and that mechanisms need to be developed to enable greater data sharing without necessarily making information public.

Priority Problem: Energy Technology Development

Participants in the Western Region workshop are intimately aware of the energy and water stresses in their region, and in particular the stresses caused by conventional electricity generation and fuel production technologies and processes. They note that **conventional thermoelectric generation technologies present a range of challenges** that will have to be met, as these technologies are likely to be in use for decades to come

- **They are water intensive.** Whether the fuel is coal or uranium, more and more thermoelectric plants are recycling their cooling water, which increases overall consumption of water (but lowers the volume of water withdrawn and returned). Such recycling today is expensive in terms of treatment (water must be treated between uses to reduce fouling of plant components); it may become more expensive as regulations and other issues force greater recycling and removal of contaminants and salts prior to disposal, thus necessitating development and installation of increasingly complex treatment equipment. Nuclear power plants tend to be more water intensive (per unit of electricity produced) than their coal-fired counterparts.
- **They present air-water tradeoffs.** By using scrubbers to reduce air pollutant emissions, plants consume additional water.
- **They present water-energy tradeoffs.** Dry or hybrid cooling systems may consume less water, but that water savings comes at the cost of generating efficiency. One participant notes that new plants are going to dry cooling simply to speed the permitting process; if water supplies are not a concern, plants can get built and operating in a more timely manner.
- **They present fuel supply problems.** Uranium is a limited resource in the United States; if additional nuclear power plants are brought on-line, the nation may find itself short of uranium within the lifetime of the plants.

Renewable energy and electricity generating technologies—hydropower plants, solar and wind technologies, corn- and biomass-based liquid fuel production, and geothermal electricity generation among others—are an area of intense interest in the region.

Such technologies, however, present problems of their own, as elucidated by participants:

- **Biofuel production** is an area of increasing interest across the region; this is exemplified by pending legislation in Washington state that would mandate their production and use. Production of these fuels presents water challenges—corn, the conventional feedstock, requires irrigation; alternative feedstocks may be less water intensive. The production processes for both ethanol and biodiesel require significant amounts of water. Biofuel production is also energy intensive; significant production of these fuels may add to the region's energy demand and stresses.
- Large-scale cultivation and harvesting of **biomass crops** for liquid fuel production or electricity generation may result in unintended water quality and quantity impacts.
- **Geothermal electricity production**—particularly the hot dry rock process—is water intensive, and suitable locations for such production are located in areas already suffering from water stresses.

- **Solar, wind, and other intermittent sources of electricity** are expensive, and their current economic feasibility is predicated on government rebates and tax incentives. Because of the intermittent nature of these generating sources, participants also note a problem with storing the electricity generated until such time as it is required on the grid.
- **Hydrogen production**, though thought to be a long-term possibility, is also noted for its potential negative impacts on water supplies, and its role in the region's energy balance.
- The region's **hydropower facilities** are aging, and the costs to rehabilitate and upgrade them are prohibitive in many cases. Because of this, the region is not realizing its full hydropower generation potential.

Participants also note that there is a significant lack of knowledge necessary to address the public's expectations of renewable technologies and the potential impact that such technologies may have on the region's energy supply. They also note a lack of environmental (externality) accounting methods that would allow comparative analysis between various energy and water technologies; in parallel, they note a lack of data on the real-world water intensity of alternative energy sources.

Alternative, non-renewable energy technologies also garnered some discussion at the meeting. Participants note a high degree of uncertainty regarding the future of **oil shale** operations in the region, but note that oil shale refining processes can be water intensive (consuming four gallons of water for every gallon of oil produced, depending upon the technologies applied) and energy intensive (requiring large amounts of energy to heat the shale to release the oil); they question the availability of water to satisfy the demands of both the shale refinery and the powerplants necessary to provide the heat. **Coal gasification** is also noted as a potentially large consumer of water, but participants are uncertain if/when this technology will be implemented.

To address this range of problems, participants cite a host of needs:

Bioenergy

The increasing interest in bioenergy (producing electricity or liquid fuels from biomass feedstocks, generating gas from anaerobic digesters) raises the concern of participants, who note a **need for site/subregional-specific economic evaluations and life cycle analyses** to evaluate the cost/energy-efficiency of such operations. They note that these should be done in conjunction with **rigorous watershed analyses** to facilitate a complete water-energy-cost analysis.

Participants also cite a **need for R&D on additional bioenergy production pathways**, citing the possibility of aquatic energy plants (producing algae for use as a biofuel feedstock), and the need to assess the impact of regulations (or changes to them) on the markets for/production of biofuels or other bioenergy resources.

Renewable Energy Technologies

Participants recognize the significant contributions that renewable energy technologies can make in the Western region, and call for Congress and DOE to **increase and stabilize funding for**

R&D on renewable energy technologies, and to focus effort on 'leapfrog' technologies and research.

Looking across the range of renewable energy technologies, participants note a **need to conduct renewable energy integration studies** to determine the impacts, benefits, and costs of large-scale/high-penetration of wind and other intermittent sources on grid operations.

Participants note specifically a **need for research on solar energy systems to reduce material costs**, and thus the relative high cost of PV cells. They cite a concurrent **need to raise solar cell efficiency to 20%**, and a **need for an analysis of market niches for solar in the agricultural industry**. Group members also call for R&D on other solar technologies (water heating, space conditioning) in an effort to make them more market competitive. They also call for R&D on tidal power technologies.

Participants also note the need for stable, predictable national policies to continue the expansion of markets for renewable energy technologies and to promote the development of domestic technology manufacturing. They cite, in particular, the **need for a consistent, long-term production tax credit**; the **need for industry partnerships to expand domestic manufacturing capacity** and eliminate the product backlog that is a barrier to adoption today; and a **need for large scale, cost-shared government-industrydemonstration projects** to pave the commercialization pathway. They also see a **need for enhanced public education** on the role and impacts of renewable energy technologies today and in the future; they see a **need for an honest information broker** and a federal role in establishing an energy-water technology transfer clearinghouse as part of this public education effort.

Coal Bed Methane

The large and growing production of methane from coal beds in the Western region (and the problems it presents) resulted in a range of needs, including:

- **Reduce CBM-associated water production**. Participants call for hydrological studies of coal seams to focus drilling in areas where less water will be produced while still facilitating gas production, and research on extraction methods that remove less water (Participants question if technology or drilling/production approaches can be developed that will increase methane production while reducing water extraction.). One participant also questions if water could be reinjected to produce more methane.
- **Enhance economics of water capture.** Participants note a need for research and development leading to the development of a cost-effective, efficient treatment system sized for deployment in small clusters of wells (50-100 wells).
- **Waste Heat**. Participants note that CBM water hits the surface at about 120F, and suggest that there is a research need to evaluate methods for capturing and making useful this waste heat.

Water Efficiency

While discussing energy technologies, participants cite a range of water efficiency needs, including:

- **Develop technologies for more efficient water use in energy producing industries**.

- **Conduct applied RD&D on materials and equipment** that will allow power plants and industrial facilities to use water of lower quality.
- **Need to develop low-emission, low water-use power generation systems** such as hybrid cooling. Participants note that current approaches such as dry cooling present energy-water-air emissions tradeoffs and significant cost penalties (0.5-5% increased costs, resulting in a $1B price tag for a new 750 MW power plant).
- **Need engineering studies to generate concepts/R&D needs targeted at reducing the costs of retrofitting once-through cooling plants to closed-cycle cooling systems**.

On the policy side, participants note that given the status quo (lack of functioning water markets), incentives should be developed to encourage the more efficient use of water in the power industry.

Hydropower

- **Develop advanced hydropower technologies**. Participants cite a need for the design and real-world demonstration of advanced conventional turbines, with research focused on lowering the fish mortality/injury rate while improving the effectiveness of turbines.
- **Conduct research and development on advanced kinetic (run-of-flow) turbines**.
- **Conduct research to increase knowledge of environmental considerations/interactions** related to hydropower, to include an enhanced understanding of the efficacy of spill; the effects of operations of aquatic environments; and to research environmental limiting factors. Participants cite the need for this research in order to scientifically determine effects on fisheries.
- **Develop the existing resource.** Participants cite the need to install additional capacity at existing hydropower facilities, and to install hydropower infrastructure at existing reservoirs that don't currently produce power.

In addition to the R&D detailed by participants, they also cite several policy-related needs:

- **Create and adopt adaptive management systems** and plans so that new scientific understanding and data can be utilized as it is generated and validated.
- **Produce and disseminate lessons learned to strengthen the "renewable energy" moniker** among the public. In coordination with this, strengthen technology transfer and transmission of success stories within the industry and among operators.
- **Research the potential for streamlining permitting**; reexamine FERC rate structures to encourage resource development through improved economics.

Miscellaneous

Participants note massive volumes of waste heat in industrial processes and in residential settings, and call for greater investigation of technologies that can capture and make useful this waste heat.

Priority Problem: Conventional Water Resources—Lack of Data and Modeling

Water opened the West and drove the development of the region—often it was the factor that, when harnessed and managed, allowed for the massive agricultural, industrial, and population growth seen in the twentieth century. The surface waters that facilitated this growth are showing signs of increasing strain:

- Salinity levels in many waterways are rising, forcing municipalities to resort to more intensive water treatment.
- Thermal pollution is increasingly becoming a concern as a result of drought-induced low flows.
- Flow disruptions as a result of extensive damming and other alterations of water courses has negatively impacted riverine and aquatic habitats.
- Increasing pollutant levels as a result of agricultural practices (pesticides, fertilizers, and selenium), recreational activities (e.g., hydrocarbon contamination from boats), and urbanization (e.g., untreated storm water runoff).

While much of the West's development was predicated on the use of surface waters, users in the region are becoming increasingly dependent upon groundwater resources as surface water sources become constrained. Participants note a range of stresses on groundwater resources in the region:

- Urban areas are pumping groundwater at rates that are thought to be unsustainable. Participants note significant non-regulated groundwater pumping and use, resulting in greater difficulties assessing the sustainability of withdrawals. Urban areas are also cited for inhibiting recharge of groundwater resources due to the "hardscaping" of recharge areas.
- Agriculture in the Western region is thought to be pumping groundwater resources at an unsustainable rate. In combination with this, participants note that the impacts (both positive and negative) of agricultural water efficiency approaches are not well understood, and may have unintended consequences (increased efficiency may result in reduced groundwater recharge, for example). Participants also cite the water quality impacts that can result from agricultural use, and comment that transfers of water from agriculture to energy or municipal uses may change the hydrology of regions, and in particular may reduce recharge of groundwater resources.
- Extractive industries (mining; oil, gas, and coal bed methane production, for example) may negatively impact the quality and quantity of water in regional and local aquifers (due to inflow/pumping and discharge), and may positively impact surface water flow regimes during operation (as a result of pumping out of mineshafts). Participants note that there is a lack of good data and models on surface waters, groundwater, and the interactions between the two to determine the cause and magnitude of these positive and negative impacts.

These problems are exacerbated by fragmented management of surface and groundwater resources in the region, **laws and regulations that have not kept up with the times** (one participant notes that every person in New Mexico is allowed to drill a drinking water well, resulting in 7000 new wells per year), **a general lack of data** on the quantity and quality of groundwater resources and their interaction with surface waters, and **limited funding available to acquire the types of data** necessary to understand and effectively manage the resources. Participants note that the United States Geologic Survey, which is responsible for surface water measurement, is losing funding for monitoring—there are now only 7,000 gauging stations, down from 8,000 in the past. In addition, participants state that USGS no longer estimates water consumption, only withdrawals. All of this, participants feel, leads to a situation where water managers don't know what waters exists now, and lack the data and tools to project and analyze what waters will exist in the future, and where.

Groundwater-related Needs

Participants cite a need for better understanding of groundwater resources, noting the need for information regarding volume, location, and quality. They comment that this understanding can be used to create much-needed cross-regional assessments of groundwater resources.

As a complement to the groundwater resource work, participants remark on the **need for a greater understanding and modeling of the interrelationships between groundwater and surface-water use.,** noting the need to understand what the hydraulic connection (or "fit) is between agricultural ditches and aquifers; to identify and map groundwater recharge areas; and to educate the public and land use planners about groundwater-surface water interactions and the importance of recharge areas.

Modeling-related Needs

Participants cite a **need for better finite element models** that are easier to use with a higher scientific reliability on yields. They also call for **easier-to-use chemical models**, for the **integration of reservoir engineering models with hydrologic models,** and for development of **models of drought** that forecast worst-case scenarios to facilitate "no regrets" planning. As data collection abilities increase, participants see **a need for DOE-sponsored planning models that take climate change into account** in water resource assessment, particularly for hydropower plant planning, development and operation.

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Participants also cite a need for a modeling platform that integrates both land and water use, noting that it should be correlated to water rights, transmission systems, irrigation, municipal water supplies, opportunity costs, population assessment, etc. To this end, they see a need for analytical tools to be developed to support these models.

To avoid recreating the wheel, participants suggest holding a "literature review" workshop with existing model owners to determine current best approaches.

Monitoring-related Needs

In conjunction with modeling, participants see a **need for an integrated measurement and monitoring system and characterization of resources**, to include **developing better aquatic toxicology measures** and understanding. They note that by developing local water quality baselines through extensive monitoring, permitting processes for energy project may be streamlined.

Data-related Needs

With the variety of water- and energy-related data sources available, and the significant gaps in understanding, participants cite a range of needs related to data, including

- Develop tools to efficiently and effectively mine existing data logs in state databases;
- Create uniform standards for data to ease its incorporation into existing and to-be-developed models
- Research methods for and approaches to dataset merging

Organizational Needs

Participants recognize the need to work within existing bureaucracies, but see significant room for improvements, including **creating interfaces between the USGS and national laboratories** to speed the development of data standards and models and **creating industry—government technology transfer consortia** that include the range of stakeholders from universities to NGOs

To facilitate data gathering and modeling activities, participants cite a **need for national funding and organization**; they note a need for a national framework that states could follow in their data gathering and collection.

Several issues are raised regarding the proprietary nature of data; one group notes that the USDA has a database of proprietary agricultural production, and that USDA's ERS can do research with the data without making it public. They wonder if DOE could appropriate this concept and apply it to energy and water while respecting proprietary issues?

Priority Problem: Alternative Water Resources—Understanding and Use

With the limited quantities of conventional surface and groundwater available for productive use in the Western region (and the declining quality of many of these resources), water managers in the Western region are beginning to look to alternative water resources—reclaimed waters are used throughout the region for non-potable applications like landscape and golf course watering; and desalination plants are increasingly common, producing high quality water for human consumption and industrial use. Produced waters—from oil, gas, or coal bed methane production—are available in large quantities in many water-scarce parts of the region, and are attracting attention as an under-utilized resource. And conservation—getting the same results from less water—is a long-recognized (but oft ignored or overlooked) method for "creating" more water.

Despite their promise, significant problems and challenges are associated with making productive use of these alternative water resources

- Several groups mention the promise of using reclaimed water for energy facilities (as cooling water in thermoelectric plants, or as process water in refineries or distilleries). These facilities, however, require a water supply that is constant in volume and quality—a challenge for reclaimed waters. Ideally, facilities using reclaimed water would relinquish rights to surface water allocations, allowing that water to be put to productive use elsewhere. However, participants note that the uncertain supply and quality of reclaimed waters leads to a dual-supply system, where reclaimed waters are used when available and suitable, but where facilities' allocation rights are retained for use when reclaimed supplies fail.
- Reclaimed waters are also suitable for domestic non-potable applications—for sanitation, individual landscape watering, and washing cars among others. This alternative water source is currently hindered by regulation and building codes that do not accommodate dual use distribution infrastructures. Matching the level of treatment to the eventual end use would save energy (by reducing treatment intensity for non-potable uses).
- Wastewater plant effluent can be (and is) used for cooling applications, but use of this alternative water resource is controversial due to unknown health risks to workers and those living around the facilities. In addition, this use may be limited due to the need to return effluent to the stream to fulfill downstream obligations (one person's waste is another's water, in many cases). Participants also mention the potential of injecting wastewater into underground aquifers for storage and eventual withdrawal and use as cooling water in thermoelectric generating facilities.
- Produced waters present similar challenges—available volumes fluctuate (for coal bed methane, volumes are initially large and then taper off rapidly over approximately five years; for water produced with oil, initial volumes are generally small, increasing over the life of the well as the oil accumulation is depleted) and qualities vary widely (from near-potable from some coal bed dewatering activities to high TDS and hydrocarbon contamination in some oil wells). In addition, produced waters face regulatory hurdles—they are classified as waste, which hampers their use, and the ownership of such waters is

open to interpretation (the producer is not necessarily the owner). Collecting produced waters is also a physical and economic challenge due to widely dispersed wellheads.
- Conserving water—using less to obtain the same results—is an alternative water source that can "free" water from one use for others. This approach faces significant challenges, however: The lack of a market in which to sell conserved water, and the difficulties in assigning a value to water, inhibit conservation; Current water treatment systems rely on a given sewage transmission velocity, which could be disturbed by large-scale conservation; The need to meet downstream obligations may make large-scale conservation impractical, although participants note that there are no analytical methodologies or total systems engineering analyses that have been done to quantify the sequential benefits and/or costs of conservation.

To address these challenges and problems, participants cited a range of needs in several categories:

Broadly-applicable R&D

Participants cite a very basic **need to understand and quantify the produced water resource** in terms of volume over time, characteristics (TDS, hydrocarbons, etc.), and location (particularly in terms of other infrastructure like transmission lines, fuel sources, etc.).

They also note a fundamental problem with understanding the disconnect between laboratory finding and field results—to solve these disconnects, they cite a **need for more realistic laboratory-based studies** and call for researchers to utilize real-world samples in their work. This work will be necessary to **develop a true understanding of the long-term impacts of surface discharge** of produced waters.

Infrastructure/Institutional issues

A host of infrastructure issues stand in the way of increased use of alternative water supplies; to overcome these barriers, participants cite needs to
- Develop a Western state-specific roadmap on the use of reclaimed waters.
- Develop guidance for plumbing and health code changes to facilitate the use of grey water in residences and businesses.
- Create incentives for builders to install dual-use plumbing systems.
- Prepare infrastructure for reclaimed municipal water use.
- Develop best practices document on the use of municipal reclaimed water in the western region.

Making beneficial use of produced waters will require overcoming similar institutional issues; participants recognize that because each state has different laws, facilitating these infrastructural changes will be difficult. To ease the transition, they call for a **series of published case studies of successful management of produced waters**, and for a greater federal role in the form of inter-agency groups that can **improve federal coordination and provide a coherent management approach**.

Beneficial Use in the Agricultural Sector

Participants note a **need to genetically engineer crops and plants to optimize their growth under the conditions expected near produced water well fields**; this research should be focused on identifying which food and bioenergy crops grow well in a produced water regime, and if bioenergy crops can be cultivated through direct produced water irrigation.

Storage

Participants note that aquifer storage may be an integral part of the alternative water picture in the future, and note a **need for more technologies related to aquifer recharge and recovery**. In conjunction with this, they call for research on aquifers, particularly related to **receptivity** and the **impacts of injecting municipal reclaimed waters** into aquifers for storage.

Analytical Comparison between Conventional and Alternative waters

Participants understand that vast quantities of alternative waters are available throughout the western region; what they don't fully understand are the true comparisons between those water sources. Regarding the use of produced waters for cooling in power plants, they cite a **need for a rigorous cost-analysis** to compare the costs of siting a power-plant by the available water vs. building pipelines to bring water; they also note a **need to understand the energy and other costs of treating produced (and effluent) waters for cooling**.

Treatment Issues

Participants cite a **need to develop less energy intensive and less costly treatment technologies** or processes in order to maximize the beneficial use of produced waters. They comment that RO processes are expensive, that ion exchange units need to change beds frequently, and that electrodialysis is not developed to full-scale. They cite a **need for improved filters or metal membranes** to removes solids and fines, and a **need for processes that are readily adaptable to site-specific water qualities**.

Of greatest interest to participants are technologies and processes that can effectively remove salts from produced waters. To this end, one group cites a **need for research on natural vegetation and animals that can purify water**.

Legal

A host of legal and regulatory issues inhibit the use of alternative water resources (produced waters, effluent, reclaimed); to overcome these, participants note needs to **clarify legal ownership** of alternative water sources to promote maximum beneficial use of the resource; **modify regulations so that water quality and end-use can be better matched** (thus allowing the appropriate level of treatment); and to **educate the public** on the use and benefits of alternative water resources.

Priority Problem: (Un)Coordinated Planning—Balancing Competing Demands

Throughout the participants' discussions, an overriding theme became apparent—one of the greatest hindrances to working at the energy-water nexus is the lack of coordinated planning within states, watersheds, and regionally.

This lack of coordination makes balancing the many competing demands in the region an ad hoc, rather than planned, process—jurisdictions (or which there are thousands) make decisions based upon what is best for them, not necessarily what is best for the common good; agencies at the state and federal levels often do not know what each other are doing, or their rules and requirements conflict; and courts and litigation have become the first resort, not the last. Participants note that there is no holistic view of water in the West, let alone a holistic view of the energy-water nexus.

The reasons behind this lack of coordination are many: The complex legal and regulatory structures that govern interactions within and between states and tribal governments; an array of laws and institutions that were well suited and appropriate for life in the west in the first decade of the twentieth century, but not necessarily for the first decade of the twenty-first century; and a disjointed federal-state ownership/management regime, among others.

The symptoms of this lack of coordination can be seen in a variety of sectors:

- There is no integrated resource planning or analysis—there are few common metrics, criteria, guidance documents, or policies outlining how water uses will be balanced and how water should be allocated (in normal times and times of stress, to include drought). Value attribution approaches are lacking.
- Water is flowing toward the dollar (generally from agriculture to energy and municipal users), with no comprehensive understanding of the short- or long-term economic, cultural, social, or environmental ramifications of these shifts.
- Cross-boundary regulatory conflicts impede water transfers, and thus the efficient use of a scarce resource.
- The local and state management of surface and groundwater is fragmented along agency lines; one participant comments that

<u>Competing Demands in the West</u>

Competing demands in the Western region are as complex as in the Central and Eastern regions, but carry more 'baggage' due to long fights over increasingly scarce resources. A sample:

- Overallocation of surface waters due to drought conditions has resulted in municipalities withdrawing increasing and unsustainable volumes of groundwater. As aquifer levels drop, greater amounts of energy are consumed for pumping—energy that is itself scarce in many parts of the region.
- Riverine and other habitat protection activities compete for water with all other users.
- Increasing costs for water (ever-thirsty municipalities are driving up the cost) are leading to changes in crop types and a reduction in farmed acreage, leading to socio-

Utah state law actually encourages this fragmentation.
- Institutional stovepiping results in a lack of interdisciplinary knowledge within agencies, which leads to fragmented and conflicting information and finally poor policy decisions regarding water use.
- Decision support tools and data are functionally non-existent.
- Federal law (Clean Water Act, Safe Drinking Water Act, National Environmental Policy Act, and Environmental Species Act, among others) constrain and influence the management of resources, which in turn impacts the balance of competing demands by *de facto* placing one use above others.
- Non-traditional costs and benefits (often to include those related to the natural environment) are not well accounted for. Participants note a lack of understanding of competition for instream flow needs.

Permitting

Several groups raise the issue of permitting of infrastructure projects, ranging from mining to power plants to subdivisions; universally, participants see permitting processes as onerous, expensive, time consuming, and (sometimes) capricious. They note a need for more flexible permitting policies and processes; standardization and clarity on process requirements (including identifying requirements vs. discretion); state- and federal-level offices to assist permit applicants through the various processes; and a quantified, rigorous, repeatable process for determining best public interest.

Land use planning

Land use planning is cited by participants as an important component in balancing competing demands, as water is a peculiarly "local" commodity. They note a need for legislation to force universal development plan review processes that treat water as they treat energy—much like the California "water in hand" legislation.

Participants also cite a need for land use plans that minimize hardscapes and maximize natural infiltration of precipitation (to aid in groundwater recharge); that encourage xeriscaping (to reduce water demand for landscaping); and that include incentives for builders to develop low impact communities.

Regulatory/Legal Constraints and Influences

To untangle the confusion that characterizes energy and water in the Western region (in many cases the experts at the meeting expressed largely imperfect knowledge), participants cite a **need for regulatory roadmap** (at the federal and state levels) to determine all interactions between organizations; they also note a need for oil and gas-specific roadmaps. When an understanding has been built through roadmaps, participants note a **need to identify inconsistencies and overcome them through increased coordination**. Participants also note **a need to identify best practices for legal requirements** for coordination and planning.

As an adjunct to these activities, participants also note a need to identify antiquated water laws for reevaluation.

Times of stress

In addition to all the usual problems with balancing competing demands, participants note that times of stress and drought exacerbate the severity of problems. With this in mind, participants cite a **need for federal assistance for drought planning** in the states and a **need to ensure that each state's laws and policies allow flexibility within water rights to accommodate drought-induced needs**.

Education

Participants note that **education is a primary need** if energy and water (and other competing) needs are to be balanced in the western region—to this end, participants note a need for a publicly-targeted study that shows how rising water prices are going to drive up electricity prices, and how redistribution of water may be necessary from a societal good point of view.

Energy-water implication studies

Several groups note a **need for integrated regional and sub-regional (e.g., utility boundary) water and energy planning** as a means for optimizing water use. They remark that traditionally energy production has been located at a ready fuel source, and only then is water supply given consideration.

To assist in this planning, participants see a **need for analyses of the effects of rising water costs on energy production costs** and pricing and to assign a water budget to projected energy needs. To conduct such analyses and assignations, the groups cite the **need for region-specific optimization tools and models** that will allow planners to properly allocate and use water based on future energy needs and other constraints (water rights, cost, demands, availability). Such models and tools must be based on water availability in each region, and as such data must be collected to establish existing aquifer quality and quantity issues (as discussed in the Conventional Water Resources section).

Participants also note that any number of organizations are involved in researching parts of this problem, and call for coordination of the agendas of major R&D players.

Modeling/Tools

Beyond the modeling approaches and tools discussed in the Conventional Water Resources section, participants note a range of competing demands-specific needs:

- Develop models/decision support tools for integrated planning. Tools should integrate water, energy, air quality issues and should include an optimization model for water allocation based on constraints (e.g., rights, cost, demands, availability, etc.) Participants note that the Delaware River Basin Commission is a good example of water resource planning, but note that even in this case power demand may not be fully integrated.
- Create water supply/demand modeling and resource analysis tools specifically for use in the planning stages of power plant development.

- Implement cost-benefit analysis—to include non-traditional costs and benefits—at a larger scale when deciding competing demands. Such analyses need to incorporate environmental issues by developing accounting spreadsheets that reflect "non-economic environmental externalities."

Federal Role

Water is, and always has been, a state's rights issue. However, participants in the Western region groups see an **increasing need for overriding federal direction on how to rank uses and how to manage waters** (perhaps through the application of a weighting matrix of sorts).

Participants also see a leadership role for federal agencies in developing federal water policies and programs with internally consistent policies that can be disseminated and utilized by states (similar to federal funding for highways and transportation—if you want federal funding for highways, you have to comply with certain requirements—such policies could rationalize water allocation and use in the states through a national loading order or sorts). Speaking to internal consistency, participants note a **need for better coordination between HQ and field operations within and between agencies**; they note that competing demands aren't just a molecules versus electrons issue, but also a Department versus Department issue in many cases.

Transboundary-watershed planning

Given the inherently transboundary nature of water (particularly artificial boundaries), participants cite a range of needs to facilitate water/energy collaborations across boundaries (tribes, states, countries, political jurisdictions, watersheds), including examining past cross-boundary collaborations that have occurred to learn from the mistakes and successes of others, and to identify and secure stable funding for collaborative transboundary management activities.

Strengthening stakeholder participation

Participants note that striking a balance in the complex world of competing uses will require the participation of all involved; they cite a need for better engagement of oft-disenfranchised groups like tribes in the process and to look for synergistic solutions for regional issues regarding air, water, energy, and transmission.

Participants also see a need for a shift in decision making processes, calling for the identification and adoption of a range of stakeholder-driven processes that can facilitate the shift from a water rights model towards a community resource model that will allow communities to manage their water.

Habitat—human use conflicts

Of the numerous competing demands, the human use—habitat requirements issue generated significant discussion, during which participants cited a range of needs to define environmental requirements, provide the water necessary to meet those requirements, and protect both the ecosystems and the supplies upon which they rely. Participants also note an overarching need to agree upon definitions: What is sustainable? Recoverable? What to restore a system to?

To **define environmental requirements**, participants see a **need for research on timing issues** (how much water needs to be where, and when); **greater data collection and analysis** focused on the site- and life stage-specific needs of aquatic ecosystem inhabitants; and **research on sustainable riparian vegetation** and associated water needs. They also call for monitoring plans to be attached to Biological Opinions of infrastructure (particularly hydropower) projects.

To provide water to meet environmental requirements, participants see a **need to allow seasonal transfer "donations"** to maintain streamflow during critical times; to **create a funding or incentive mechanism** (User fees? Taxes?) for acquiring in-stream flow volumes; to integrate produced water into watershed management (beneficial use); and to **alter state law so that in-stream water uses can compete equally with other uses**.

To protect water provided for environmental requirements, participants cite a need for regulation, legislation, or policy that will ensure that water put into the river stays in the river.

Priority Problem: Climate Change

Climate change is, according to participants, an overarching issue that can impact (and in some cases has impacted) energy production, agriculture, and recreational and environmental uses of water in the Western region. Participants note that climate change may impact the temporal and spatial distribution of precipitation in the region, with significant concerns

- Low snowpacks in the Pacific Northwest will impact the generation of electricity from hydropower facilities—less snow in the mountains, less water behind the dams, less electricity that can be produced;
- Changes in traditional rainfall patterns may impact snowpack melt, making water unavailable at hydropower facilities when needed;
- Lower volumes of surface water as a result of precipitation shifts will further impact those uses that compete with ESA and NEPA-mandated flows;
- Large variations in precipitation (shorter duration, more intense events) may cause catastrophic failure of hydropower facilities and other water impoundment structures;

It is not just precipitation shifts that worry participants; they note that earlier springs and later autumnal seasons will result in longer summers, perhaps increasing overall demand (agriculture will have a longer growing season) and extending "peak" water demand periods. Participants also note that precipitation and temperature shifts may impact crop dependability, which in turn may impact the production of both corn and cellulosic ethanol.

To address these looming problems and challenges, participants cite the **need to assess the impacts of climate change** including water quality, water availability, seasonal timing, and variability on hydropower operations. The note a **need to understand and project potential impacts of climate change** on water supplies, and to develop adaptive planning, management and mitigation scenarios.

Climate change impacts on hydropower generation

Participants comment that hydropower generation capacity and facilities are extremely vulnerable to climate change caused shifts in precipitation patterns and volumes. To understand the global impacts, participants call for modeling efforts to understand the global climate change impacts of severely reduced hydropower generation. They cite a need for combined technology and economic modeling and construction of "What if" scenarios to discern the economic issues and technology—economic tradeoffs.

Climate change impacts on water supply

Participants are quite certain that climate change will impact the water supply in the western region; it is the when, where, and how badly that they do not know. To this end, participants call for modeling efforts to examine long-term water supply in the region and to identify the water infrastructure that will be needed under climate change scenarios. They note a range of interrelated issues that need to be addressed, including a need to understand the impact of land cover and land use changes and flood plain shifts/alterations on groundwater recharge.

Looking to the causes rather than the impacts, participants would like to see a quantification of the greenhouse gas reductions that could be realized from water and energy efficiency programs, asking if such programs would actually make a global difference.

Biological impacts

Participants note **a need for data and information on the likely biological needs of fish and wildlife under climate change scenarios**, and to develop processes for optimizing the selection of impact mitigation approaches. To this end, participants note a need for generic information on the costs of different mitigation approaches based on types of stream, geomorphology, etc.

Climate change-specific modeling

Participants note a need to build energy-water specific regional models of climate change that are built to provide detail at the watershed and river basin scale. They note that these models will demand more **research be directed to understand the hydrologic cycle**, particularly as implications from temperature changes can be drastic—lower soil moisture, less snow pack, etc., can mean significant impacts. Similarly, participants note the **need for probabilistic spatial and temporal predictions of drought conditions** and future temperature, run-off, etc. that impacts water supplies for energy production; such forecasts should assign dollars and economic impact for probabilistic scenario outcomes.

In the interests of seeing these models used and understood, participants note a **need to introduce climate modeling research to water planners and managers** and to incorporate climate modeling research into the water and energy policy planning arenas. To this end, there is a **need to develop and cultivate more people who can do "translational" science** to convey information to policy makers.

Priority Problem: Cost/Value/Ownership of Water

Underlying many of the water and energy stresses facing the Western region is, according to participants, the inappropriate valuation of water and the complex ownership and use structures that determine and sometimes constrain its use.

Participants note that presently, water pricing is independent of any intrinsic value, leading to a scarce resource being allocated to uses that do not provide the greatest economic benefit. They comment that there is no system in place to address the temporal and spatial value of water, the opportunity/time costs, or to react to the quick changes in the real cost of water. In addition, they note that water is unevenly subsidized throughout the region. The result of this is a lack of market price signals for all users, and a hampering of the efficient use of the resource.

Participants note that the complex water ownership frameworks in the Western region restrict the efficient use of the resources—new water permits are protested by existing permit holders, adding time and cost to obtaining water; much of the water resource in the region has not been adjudicated, leaving "true" ownership of the resource confused; state laws often prohibit the transfer or sale of water or water rights, thus inhibiting the creation of a market that could help in delivering price signals and thus assigning a cost and true value to water. They also note that where waters could be put into productive use (in particular produced waters from extraction activities), confusion surrounding legal ownership of such waters often hinders their use.

Property Rights

Participants cite a range of needs related to property rights and the legal structure of water:

- **Need firm property rights to enable markets**. This will require overcoming concerns about water transfers as well as developing some mechanism for addressing wealth losses and compensation.
- **Need to quantify existing rights**—federal reserve rights (e.g., tribal rights) and regulatory rights, for example. To this end, participants see a **need to match water rights to hydrographics** in order to translate old rights to current day and year to year, and a need for predictive models to discern emerging rights problems. Such activities will **require a standard methodology or protocol** that is followed by all states, thus easing cross-state comparisons.
- **Need to create database(s) of water rights per drainage**, and make the database(s) accessible to all. In conjunction with this, participants see a **need to create an index of reliability for water rights** and to conduct opportunity cost analyses on these rights.

Pricing Mechanisms

Participants see a host of problems with current pricing mechanisms, and a range of needs to address them. They call for **progressive, tiered pricing structures for water** where large users incur the highest prices, noting that this will more accurately reflect the true price of power and water. Participants also recognize the necessity of capturing externalities and non-economic benefits, and thus see a **need for an equitable rate structure for competing uses of water**.

Noting that such pricing structures will not be put in place overnight, they call for a **mechanism to gradually increase the price of water** and thus manage the shift and avoid waste of water.

Participants are also aware of the significant impacts that such pricing shifts could wreak, and thus call for **research that evaluates the impacts of current and proposed pricing policies** with regard to both water and energy and the end-consumers thereof.

Fundamental analysis—is the system broken?

While many participants feel the nation's water system is fundamentally dysfunctional, some question this assertion. They see a **need for an analysis of federal power/water price interactions** to determine if they encourage or discourage efficiency. Other groups **call for an open ended, non-hypothesized study, measurement, and analysis of subsidies** to investigate impacts on land use, food production, and the environment and to determine which subsidies "make sense" in terms of optimal use of water and energy.

Externality Valuation

Participants note a **need to develop a better understanding of the economic value of water used for environmental purposes** (habitat maintenance, wildlife, etc.). They also note a **need to devise methodologies to assign dollar values to aesthetics** (viewsheds and flowing rivers, for instance).

Priority Problem: Lack of National Water Efficiency/Use Standards

Water is often not effectively or efficiently used in the United States. Participants cite inefficiencies in all end-uses from the urban sector (consumption of treated water for non-potable uses like landscape/lawn watering, car washing, etc.) to the agricultural sector (over irrigation as a result of 'use it or lose it' regulations). Among the range of factors that contribute to these inefficiencies (see section on the price/value of water, for instance) is the lack of national efficiency or use standards. They note that in the agricultural sector, energy prices are the biggest driver of water efficiency (the higher the energy cost, the greater the cost to pump water, and the reduced revenue for the crop).

Participants comment that serious conservation takes place when society finally recognizes there isn't enough water, noting that no real serious effort has been expended to consider the potential of conservation. To jump-start the national consciousness, participants note the following needs and activities:

- **Develop a suite of tools to improve water efficiency in the agricultural sector.** Participants note a need for creating drip irrigation system durability standards; development of improved irrigation controllers that are smart, easy to use, and affordable; research on crops that are less water intensive; and improved irrigation load forecasting.
- **Develop methodologies for defining the volume of water conserved.** In conjunction with water valuation tools, this will be necessary to determine the costs and benefits (and thus worth) of conservation.
- **Develop and implement a national "Water Star" program** modeled on the successful Energy Star program. Such a program would focus on developing water efficiency metrics and standards for residential and commercial appliances, as well as serving as an education/advocacy conduit for communicating and disseminating information about the importance of non-drought-period water conservation. Participants feel the program should also incorporate a recognition program (in lieu of financial incentives, public recognition may serve to spur conservation).
- **Enhance federal role in water conservation technology development.** Participants note that there is a large technology commercialization gap currently; technologies and methods are developed, but not implemented. They see a federal role in testing or certifying technologies to hurdle the commercialization gap. Participants also call for increased federal funding of R&D in this area; they not that federal cost shares have been dwindling.
- **Identify incentives/subsidies to promote conservation and/or recycling.** Participants suggest that tax rebates be investigated, that outreach toward home builders be conducted in an effort to identify incentives for more efficient home construction, and that the feasibility of instituting a severance tax on water lost due to a lack of recycling/conservation be considered.
- **Incorporate water efficiency and conservation into Federal programs** and purchasing. Federal equipment specifications and purchasing policies should be

modified to consider water efficiency. Revolving loan programs for efficiency measures and equipment should be organized on the national level.

- **Develop approaches whereby conserved water can be sold**; in parallel, transaction costs between buyers and sellers should be reduced in some fashion.
- **Address residential water efficiency through modification of building codes to permit use of grey or recycled waters.**